Petrology of the crystalline rocks hosting the Santa Fe impact structure

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Background

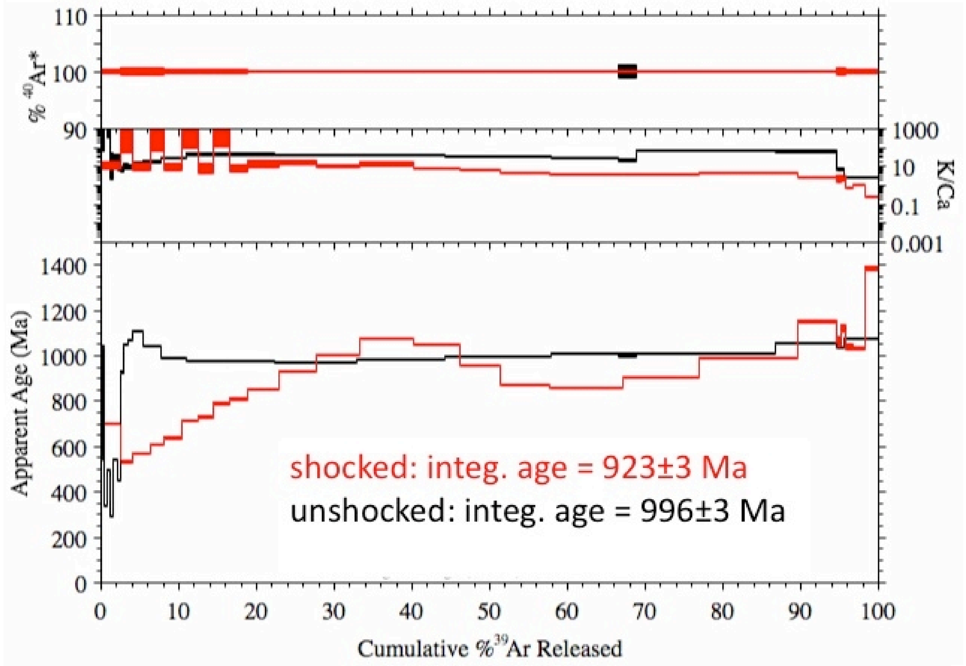
The Santa Fe impact structure (19°58′ N, 76°31′E) was recently identified by the presence of shatter cones in the Proterozoic crystalline rocks of the southern Sangre de Cristo Mountains of northern New Mexico [1]. The shatter cone-bearing lithologies contain planar deformation features (PDFs) in quartz and other microscopic evidence of shock [2].

A shatter cone along Hwy. 475. Image from French & Koeberl [3].

The host rocks are complexly tectonized and deeply eroded. No crater morphology is preserved, but the original crater is estimated to have been 6-13 km in diameter [2].

Preliminary geochronology

Preliminary $^{40}Ar/^{39}Ar$ analysis of K-feldspar separates from a shatter cone-hosting sample and an unshocked country rock sample constrain the likely age of impact (from Newsom et al. [4]):



• Both samples show cooling below the K-feldspar closure temperature at ~1000 Ma. This is consistent with other ages of regional uplift [5].

• Both samples show Ar loss by diffusion at ~450 Ma. This is consistent with the age of the ancestral Rocky Mountain orogeny [5].

• The shocked sample shows greater greater Ar loss that extends to higher temperatures. This may be due to the presence of subdomains caused by micro-fracturing in the shocked samples. This hypothesis requires confirmation.

• If the diffusion pattern in the shocked sample is due to impact micro-fracturing, this brackets the impact age to >450 Ma.

Purpose

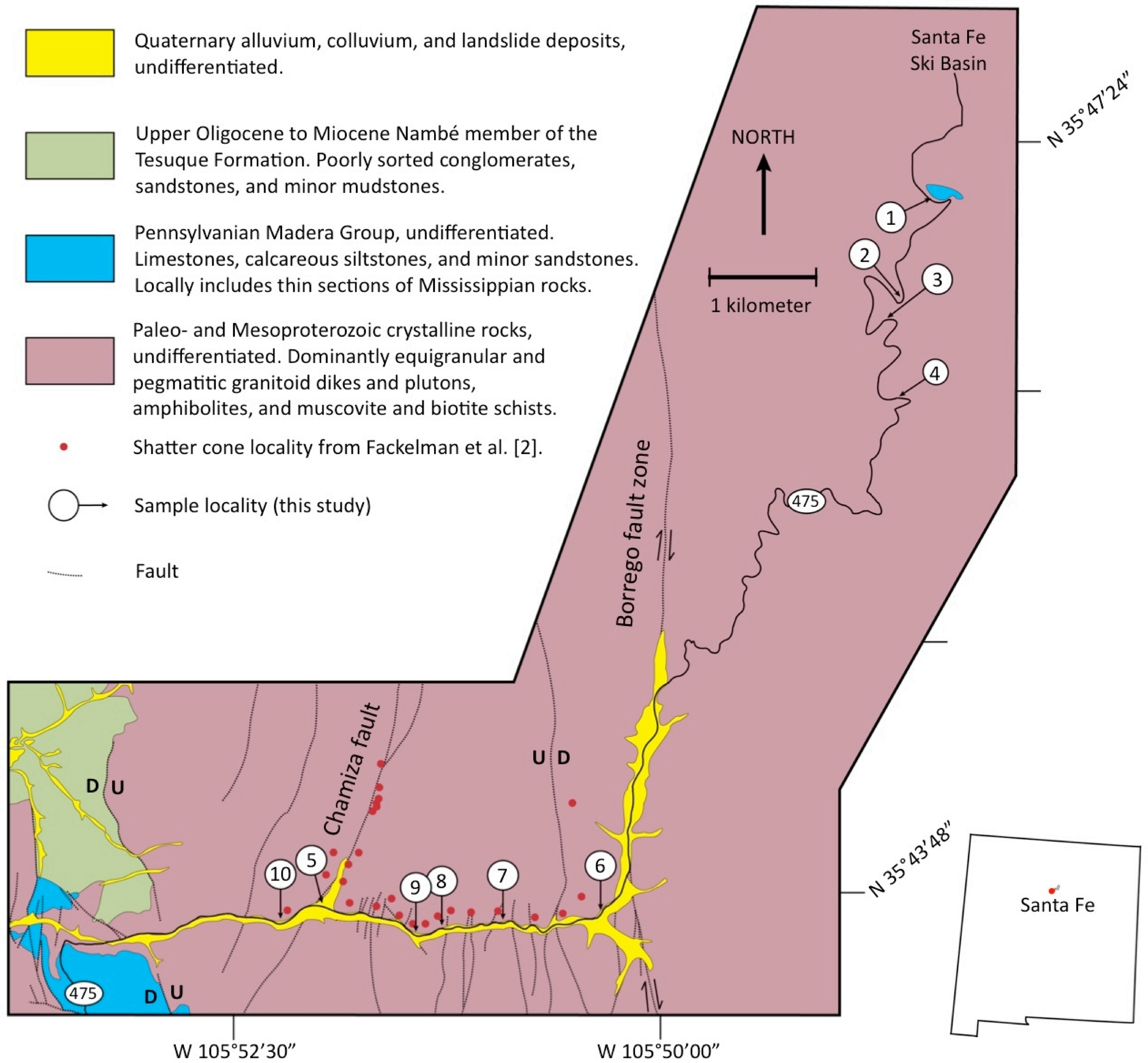
We collected samples from within the area of shatter cone occurrence and for ~8 kilometers (map distance) along the roadway. Our primary goal is to date the impact. Our secondary goal is to use the petrology and Ar systematics to provide further insight into size and scale of the impact. Our approach is to:

• Conduct a detailed petrology study to identify lithologies that share petrologic characteristics and tectonic histories but with differing degrees of shock.

• Obtain micro-cores of K-bearing minerals from multiple samples for $^{40}Ar/^{39}Ar$ analysis.

• Examine the Ar diffusion patterns for multiple minerals in multiple shocked and control samples.

This will help us to better understand outcrop and regional scale relationships among rocks and their responses to the impact event.

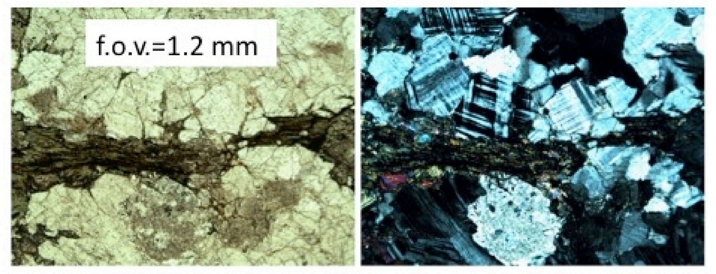


Map geology is adapted from Read et al. [6] and Bauer et al. [7]. The shatter cone localities are those sampled by Fackelman et al. [2]. Circled numbers indicate sites sampled for our study.

Selected sample sites

East of Borrego fault zone

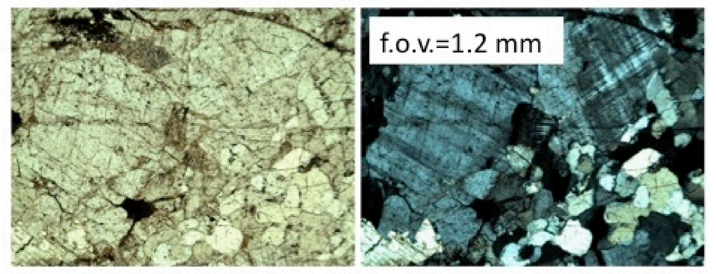
3 (A) foliated m.g. gray granite (right)
(B) non-foliated c.g. granite dike



Biotite foliation in metagranite (3-A).

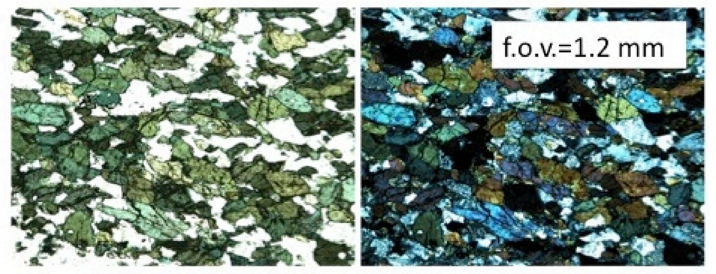
Shatter cone region

6 (A) foliated m.g. pink bt-granite (right)
(B) pink pegmatite dikes
(C) amphibolite gneiss



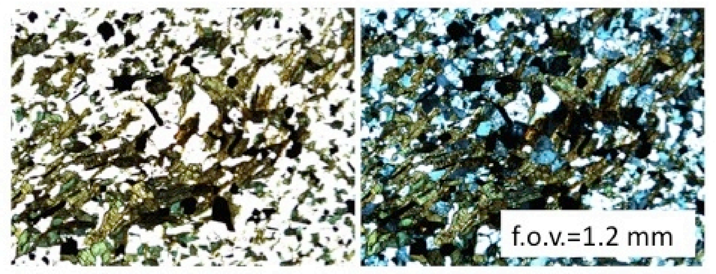
Bt-granite (6-A).

7 (A) m.g. pink hb-granite
(B) pink pegmatite dikes
(C) amphbolite (right)



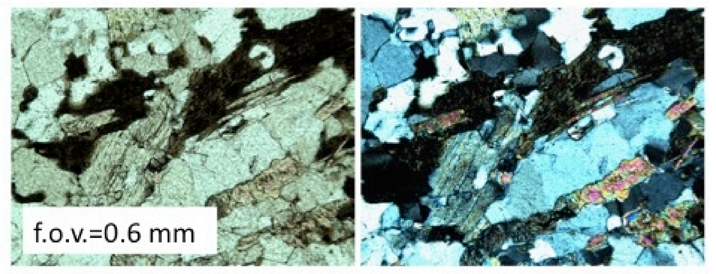
Amphibolite (7-C).

8 (A) musc-schist
(B) bt-amphibolite (right)



Spaced bt-FeTi oxide foliation in amphibolite (8-B).

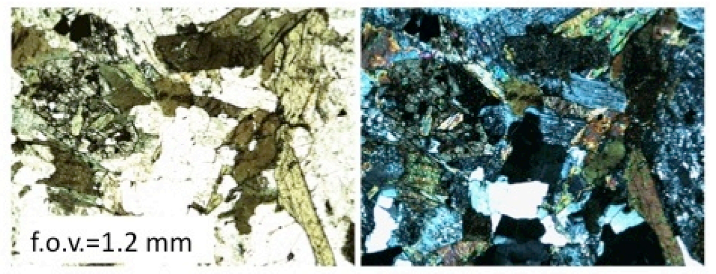
9 (A) gneissic granite
(B) pink c.g. mus-granite
(C) mus-bt schist (right)



Muscovite and muscovite-biotite foliations in schist (9-C).

West of Chamiza fault

10 (A) bt-amphibolite
(B) pink c.g. mus-granite, brecciated
(C) m.g. cpx-hb-bt granodiorite (right)
(D) pink m.g. bt-granite



Cpx, hb, and bt in granodiorite (10-C).

[1] McElvain et al. (2006), *GSA Abstracts with Programs* 38, 7, 298. **[2]** Fackelman et al. (2008), *Earth Planet. Sci. Lett.* 270, 290-299. **[3]** French & Koeberl (2010), *Earth Sci. Rev.* **98**, 123-170. **[4]** Newsom et al. (2007), *Met. Planet. Sci.* (supp. 1) 42, A117. **[5]** Sanders et al. (2006), *GSA Bull.* 118, 11-12, 1489-1506. **[6]** Read et al. (2000) N. Mex. Bur. Geol and Min. OF-GM 32, 1:24,000. **[7]** Bauer et al. (1997), N. Mex. Bur. Geol and Min. OF-GM 07, 1:24,000.